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PROGRAMS FOR THE TRANSONIC WIND TUNNEL DATA PROCESSING INSTALLA--ETC(U)
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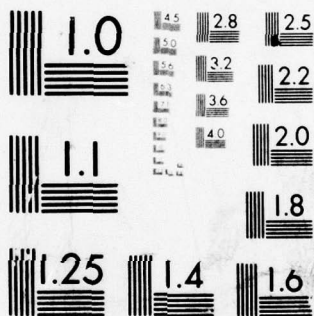
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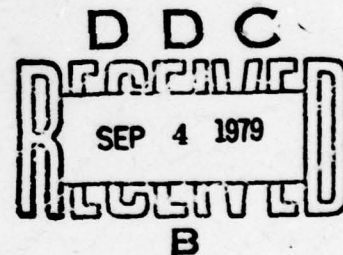
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AERONAUTICAL RESEARCH LABORATORIES

MELBOURNE, VICTORIA

Aerodynamics Technical Memorandum 314

PROGRAMS FOR THE TRANSONIC WIND TUNNEL DATA
PROCESSING INSTALLATION - PART 7 - EXTENDED FOCAL

N. POLLOCK



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SUMMARY

↓ Since the transonic wind tunnel data processing installation, which is based on a PDP 8-I computer, was installed in 1968 a considerable library of standard programs have been produced. This program library covers all types of testing commonly carried out in the wind tunnel. However there remains the possibility of unusual tests being required which are not covered by existing programs.

This memorandum describes modifications to the Digital Equipment Corporation FOCAL language (FOCAL is a keyboard oriented interpretive language similar to BASIC) which permit the tunnel instrumentation, display and plotter to be operated by FOCAL programs. Using this extended FOCAL language it should be possible to rapidly write and de-bug programs to meet unusual requirements not covered by the standard program library. ↗

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DOCUMENT CONTROL DATA

DISTRIBUTION

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1. INTRODUCTION

In 1968 a data processing installation based on a PDP 8-I computer was installed in the transonic wind tunnel. Since that time a considerable number of standard programs have been produced which cover all types of testing commonly carried out in the transonic tunnel. The current standard library includes programs to:

- (a) compute and display tunnel Mach number¹,
- (b) collect, reduce to coefficient form, display, plot, print and store on DEC tape, pressure measurements obtained from multiple Scanivalves²,
- (c) collect, reduce to body axes coefficients, shift to wind axes coefficients, display, plot, print and store on DEC tape, six component force measurements^{3,4},
- (d) perform curve fitting, axes shifting and matrix inversion to assist with strain gauge force balance calibration⁵,
- (e) translate tunnel force and pressure data into a DEC tape format compatible with the site PDP 10 computer system⁶,
- (f) cross plot a wide range of force coefficients against one another,
- (g) edit data and produce formatted print out suitable for direct reproduction in publications.

The majority of the standard programs are written in assembly language (PAL-D)¹¹ to make maximum use of the available core storage (12K words).

It is probable that from time to time unusual tests will be required which are not covered by the standard programs. If the task is of sufficient magnitude, writing a new assembly language program or modifying an existing program would be justified. If the task is a minor one the program writing and de-bugging time would not be acceptable.

In this memorandum modifications to the Digital Equipment Corporation FOCAL language are described which permit FOCAL programs to operate all the tunnel instrumentation, the display and the plotter.

FOCAL is a keyboard oriented, conversational, interpretive language similar to BASIC with real time de-bugging so program development is rapid. Using the extended FOCAL language described here it should be possible to quickly develop new data handling programs. Due to the limited variable storage and the slow speed of execution, FOCAL data reduction programs are not suitable for major tasks which involve large quantities of data.

The extended FOCAL language and the FOCAL routines presented here were originally written in the period 1974-1976. When necessary program modifications were carried out to keep up with system hardware changes. The version of extended FOCAL presented here is compatible with the current (Feb. 1979) hardware configuration.

2. PROGRAM USAGE

2.1 Loading and Operating

The present extended FOCAL program is stored as three systems programs FC29, FCL9 and ST9K. The procedure for loading from the disk is:

- . FC29
- . FCL9
- . CALL (USER PROGRAM)
- . ST9K

If no user program is to be loaded the dummy program NUL9 must be called. When successfully loaded the program types:

? 00.00
*

The program is then ready to accept a command^{7,8} from the teletype.

Since extended FOCAL operates with the interrupt turned off the +C keyboard interrupt does not work. To persuade the program to listen to a command when it does not want to, it is necessary to stop and restart at 0200 in Field 0.

2.2 Capabilities

All the standard capabilities^{7,8} of FOCAL 8, 1969 including the extended functions are still available. The 8K overlay^{7,8} is incorporated and there is storage available for 8000 (decimal) characters of indirect program and 124 (decimal) identified variables.

The new functions that have been added are described below:

- (i) FNEW (\emptyset , X). Read input from device number X. The current device numbers are listed below:

Device Number (decimal)	Input	
1	P	(Static Pressure)
2	H	(Total Pressure)
3	P_b	(Base Pressure)
4	Z	(Normal Force)
5	M	(Pitching Moment)
6	X	(Axial Force)
7	Y	(Side Force)
8	N	(Yawing Moment)
9	L	(Rolling Moment)
10	\emptyset	(Incidence)
11	\emptyset_b	(Balance Roll Angle)
12	\emptyset_m	(Model Roll Angle)
13	T	(Temperature)
14	Ident No.	
15	Job No.	

The FNEW (\emptyset , X) Function returns to Focal with an integer value containing all the significant figures from the device selected i.e. a temperature of 16.2 \emptyset will be read as 162 \emptyset . Therefore when reading P, H, P_b , \emptyset , \emptyset_b , \emptyset_m or T the value returned by the FNEW function must have a decimal point inserted at the appropriate point. Readings of the strain gauge equipment outputs Z, M, X, Y, N and L and the temperature T must be initiated from the record push button. Details of the necessary programming is contained in (vi) below:

- (ii) FNEW (1, X). Display integer part of X (< 2 $\emptyset\emptyset\emptyset$) on Machmeter. This function, and all the other new functions which do not return to FOCAL with a numerical result, is called by an instruction like SET Q = FNEW where Q is a dummy variable reserved for this purpose.
- (iii) FNEW (2). Start data logger scan.
- (iv) FNEW (3). Stop data logger scan and return Scanivalves to port \emptyset .
- (v) FNEW (4, X).
X = \emptyset , Read data logger byte 1.
X = 1, Read data logger bytes 2 and 3.

Byte 1 is an integer where the hundreds digit is the Scanivalve number and the tens and units digits the port number.

Bytes 2 and 3 give an integer containing the sign and significant figures of the analogue to digital converter output. When using extended Focal, bytes 2 and 3 must be read immediately after byte 1 and if a number of readings are to be taken from the data logger they must be read consecutively without any intervening programming. The following program example will read and type out N data logger readings at logger stepping speeds of up to 10 per second.

```
1.02 SET Q = FNEW (2)
1.04 FOR A = 1, 1, N; DO 2
1.06 SET Q = FNEW (3)
1.08 FOR A = 1, 1, N; DO 3
1.10 QUIT
```

```
2.01 SET X(A) = FNEW (4, 0)
2.02 SET Z(A) = FNEW (4, 1)
```

```
3.01 TYPE X(A), Z(A), :
```

- (vi) FNEW (5). This function checks the state of, and then clears, the record push button flag. If the flag is set, the function returns with the value 4096, if not, with the value 0. As noted previously readings of temperature and strain gauge gear output are initiated by the record push button. These readings must be taken as soon as the button is pushed. The following program example reads and types out T, Z, M, X, Y, N and L when the record button is pressed:

```
1.02 IF (FNEW (5)) 1.02, 1.02, 2.05
2.05 S T = FNEW (0, 13)
2.07 FOR A = 4, 1, 9; SET X (A) = FNEW (0, A)
2.08 GOTO 3.03
3.03 TYPE T, !
3.05 FOR A = 4, 1, 9; TYPE X (A), !
3.07 QUIT
```

- (vii) FDIS (0, Z, X0, Y0, X1, Y1)

This function is used to operate the VT01 storage display unit¹⁰. The operations available are listed below:

Z = 0) Erase screen

Z = 1 Draw a linear vector from X0, Y0 to X1, Y1

- Z = 2 Draw an arc of 5.625° clockwise starting at X_0, Y_0 centred at X_1, Y_1 .
- Z = 3 Draw an arc of 90° clockwise starting at X_0, Y_0 centred at X_1, Y_1 .
- Z = 4) Display joystick cursor.
- Z = 5 Plot a point at X_0, Y_0 .
(Set $X_1 = X_0$ and $Y_1 = Y_0$).
- Z = 6 Plot a (O) symbol at X_0, Y_0 .
(Set $X_1 = X_0$ and $Y_1 = Y_0$).
- Z = 7 Plot a (+) symbol at X_0, Y_0 .
(Set $X_1 = X_0$ and $Y_1 = Y_0$).
- Z = 8) Read X coordinate of cursor
(Function returns with $1024 + X$)
- Z = 9) Read Y coordinate of cursor
(Function returns with $1024 + Y$)
- Z = 10) Check state of and then clear cursor interrupt flag. If flag is set, the function returns with the value 4096, if not, with the value 0.

The visible area of the screen is approximately $X = \pm 256$, $Y = \pm 320$, the total addressable area is ± 511 units square.

(viii) FDIS (1, Z, X, Y).

This function is used to operate the calcomp 565 incremental plotter. The operations available are listed below:

- Z = 0) Reset plotter coordinates to 0, 0.
- Z = 1 Pen up - move from current location to X, Y in a straight line.
- Z = 2 Pen down - move from current location to X, Y in a straight line.
- Z = 3 Plot a (+) symbol at X, Y.
- Z = 4 Plot a (X) symbol at X, Y.

The value of Y used must be in the range 0 to 4096 and, if the plotter coordinates are reset with the pen aligned with the right hand border, X may vary in the range 0 to 1000. The positive direction of X and Y pen travel is leftwards and upwards.

2.3 Examples

The following program segments for use with extended FOCAL cover some of the foreseeable possible requirements. It is intended that these examples illustrate the type of problem that is suited to this approach rather than being a comprehensive compendium of user programs.

(a) Mach number display.

When the tunnel is being operated with a FOCAL data handling program the normal assembly language Mach number generation and display routine¹ cannot be used. Since a display of Mach number is usually required for tunnel speed setting, any FOCAL program for use with the tunnel will require its own Mach number display routine. The following program segment executed at convenient intervals will meet this requirement:

```
31.01 S P = FNEW (0, 1); S H = FNEW (0, 2)
31.02 I (H - P) 31.03, 31.04, 31.04
31.03 S H = P
31.04 S M = FSQT (5*(FEXP(0.2857* FLOG(H/P))-1))
31.05 S D = FNEW (1, M* 1000)
```

(b) Indicated airspeed display.

On occasions when operating the tunnel at low speed it is more useful to display indicated airspeed (IAS) rather than Mach number. The following routine displays IAS on the Machmeter.

```
31.01 S P = FNEW (0, 1); S H = FNEW (0, 2)
31.02 I (H - P) 31.03, 31.04, 31.04
31.03 S H = P
31.04 S IA = 1479.1 * FSQT (FEXP(0.2857* FLOG ((H - P)/
2992.1 + 1))-1)
31.05 S D = FNEW (1, IA*10)
31.06 F D = 1, 1, 50. S E = 0
31.07 G 31.01
```

The display is in the form XXX.X knots.

(Note: the fixed hardware decimal point location must be ignored). If it is desired to display speeds above 199.9 knots the implicit decimal point location may be moved one place to the right by deleting the multiplying factor *10 from line 31.05. To change the units of the displayed speed simply alter the multiplying factor in line 31.05. Lines 31.06 and 31.07 cycle the routine at a convenient rate but if the routine is to be called from the main program when required, these two lines should be omitted.

(c) True airspeed display.

It may sometimes be required to display true airspeed (TAS) when operating the tunnel. This poses the problem that the temperature which is required for the computation of TAS can only be read when the record push button is pressed. The following program uses the waiting time between TAS computations looking at the record push button. Each time the button is pressed the temperature used by the program is updated to the current value.

```

30.01 F E = 1, 1, 20; D 31
30.02 S P = FNEW (0, 1); S H = FNEW (0, 2)
30.03 I (H - P) 30.04, 30.05, 30.05
30.04 S H = P
30.05 S M = FSQT (5 * (FEXP (0.2857 * FLOG (H/P)) - 1))
30.06 S D = FNEW (1, M * A * 10); G 30.01

31.01 S D = FNEW (5)
31.02 I (D) 31.03, 31.03, 31.04
31.03 R
31.04 S T0 = FNEW (0, 13)
31.05 S TT = (T0/10 + 273.2) * 1.8 / (1 + 0.2 * M^2)
31.06 S A = 29.091 * FSQT (TT)
31.07 S E = 20; G 30.06

```

The display units and decimal point location are identical to the IAS program described previously.

(d) Free stream kinetic pressure display.

To simplify the reduction of low speed data to coefficient form it may sometimes be convenient to operate the tunnel at a constant free stream kinetic pressure ($\frac{1}{2}\rho V^2$). The following routine displays $\frac{1}{2}\rho V^2$ on the Machmeter.

```

31.01 S P = FNEW (0, 1); S H = FNEW (0, 2)
31.02 I (H - P) 31.03, 31.04, 31.04
31.03 S H = P
31.04 K = (5 * (FEXP (0.2857 * FLOG (H/P)) - 1)) * P * 0.02371
31.05 S D = FNEW (1, K * 100)
31.06 F D = 1, 1, 50; S E = 0
31.07 G 31.01

```

The display is in the form XX.XX kPa.

(Note: the fixed hardware decimal point location must be ignored). As before the units and the implicit display decimal point location may be changed by altering the factor in line 31.05.

(e) Function plotting on the screen.

When examining the results of mathematical analyses it is often helpful to plot the functional relationship between variables. For complex functions this can be a laborious procedure if done by hand. The following program can be used to quickly plot functions on the screen:

```
1.01 S Q = FDIS (0, 0)
1.02 F X = 300, 1, 300; D 2
1.03 Q

2.01 D 3
2.02 S Q = FDIS (0, 5, X, Y, X, Y)
```

Group 3 lines define the function $Y = F(X)$ scaled so that as X varies from -300 to +300, Y varies in the range ± 380 . Alternatively if X and Y are both functions of Z line 1.02 can be used to increment Z and both X and Y defined in group 3 lines.

In Fig. 1 an example of the type of plot that can be produced is presented. The function plotted in this figure is:

$$X = 240e^{-0.1Z} \sin Z + 100e^{-0.2Z} \sin 20Z \sin Z$$

$$Y = 240e^{-0.1Z} \cos Z + 100e^{-0.2Z} \sin 20Z \cos Z$$

where Z varies from 0 to 28 in 0.005 increments.

(f) Function plotting on the plotter.

Functions can be plotted on the plotter in a similar manner to that described above for the screen. On the plotter better results are obtained by drawing straight lines between adjacent computed (X, Y) points rather than simply plotting the points. A basic function plotting program is presented below:

```
1.10 S Q = FDIS (1, 0)
1.20 S X = 0; D 3
1.30 S Q = FDIS (1, 1, V, Y)
1.40 F X = 0, 1, 1000; D 2
1.50 Q

2.10 D 3
2.20 S Q = FDIS (1, 2, V, Y)

3.01 S V = 1000 - X
```

Group 3 lines define the function $Y = F(X)$ scaled so that as X varies from 0 to 1000 Y varies in the range 0 to 4096.

In Fig. 2 a sample plot is reproduced. The function plotted is $X = 200 + 100 (Z + 0.3 \cos 62.84Z)$

$$Y = 500 + 300 (e^{-0.35Z} \sin 3.14Z + 0.1 \sin 62.84Z)$$

where Z varies from 0 to 10 in 0.005 steps.

(g) Non standard real time display.

The standard force reduction program has facilities for the display of the six force and moment components as functions of either Mach number, sideslip or incidence angle. If a real time display of a cross plot between two force components, or some other non standard display, is required a FOCAL program can be written to produce it. The following example plots the transonic range parameter Mach number X Lift/ Drag ($\frac{ML}{D}$) as a function of Mach

number (M). Each time the record push button is pressed a point is plotted on the display and the values of M and $\frac{ML}{D}$ are printed on the teletype.

```

1.01 C ERASE SCREEN AND DRAW AXES
1.02 S Z = FDIS (0, 0)
1.04 S Z = FDIS (0, 1, -250, -310, -250, 310)
1.06 S Z = FDIS (0, 1, -250, -310, 250, -310)

2.01 C PUSH BUTTON?
2.03 I (FNEW (5)) 31.01, 31.01, 3.02

3.02 C READ Z, M, X, Y, N, L AND THETA
3.04 F A = 4, 1, 10; S X(A) = FNEW (0, A)
3.06 C APPLY BALANCE INTERACTIONS
3.08 S Z = ZZ*X(4) + ZM*X(5) + ZX*X(6) + ZY*X(7) +
      ZN*X(8) + ZL*X(9)
3.09 S X = XZ*X(4) + XM*X(5) + XX*X(6) + XY*X(7) +
      XN*X(8) + XL*X(9)
3.11 C CALCULATE L AND D
3.13 S L = -Z* F cos (X(10)/5729.6) + X* F sin (X(10)/
      5729.6 )
3.15 S D = -X* F cos (X(10)/5729.6 - Z* F sin (X(10)/
      5729.6 )

4.02 C DISPLAY POINT
4.04 S Z = -310 + 25*M*L/D
4.06 S X = -250 + 500*M
4.08 S L = FDIS (0, 7, X, Z, X, Z)

```

5.10 C PRINT M AND ML/D
5.12 T %6.03, M, " ", M*L/D, !
5.14 G 2.03

31.01 C MACH ROUTINE, SEE EXAMPLE A.
LAST INSTRUCTION G 2.03

The variables ZZ, ZM, ZX etc. used in lines 3.08 and 3.09 are equal to the product of the appropriate sensitivity and inverse balance calibration matrix element. Using the terminology of reference 4:

ZZ = SZ.k'ZZ, ZM = SM.k'ZM, etc.
XZ = SZ.k'XZ, XM = SM.k'XM, etc.

3. PROGRAM DETAILS

3.1 Present version

A complete listing and symbol table of the present version of the FOCAL modifications are presented in the appendix. The core locations used are:

- (a) Field 0, 0035, 0377, 0410 and 4400 to 4577
- (b) Field 1, Nil
- (c) Field 2, 0200 to 2177 and 6200 to 6777.

The remainder of Field 2 is available for additional new functions. Since the 8K overlay is used Field 1 must be left blank.

It was decided to exclude operation of the line printer and DEC tapes from the current version. This was done because a general operating routine for these devices would have been long and complicated. If a need arises for a FOCAL program to control the printer or DEC tapes it is suggested that a specific assembly language segment be written to cover the particular requirement.

3.2 Modifications

The following hints are aimed at assisting anyone who wishes to add further new functions to the current version of extended FOCAL. The best guide to new function writing is given in Ref. 9 a copy of which is held by the author. The various listings and symbols tables given in Refs. 7-9 do not agree with each other or with the FOCAL program which we have. When modifying FOCAL itself it is necessary to refer to a disassembly of the actual program.

The current program has two convenient entry points to further new functions. The FNEW function has been used for values of the first argument of the function from 0 to 5. If the FNEW function is used with a first argument greater than 5 the program will arrive at the error return at 4473 in field 0 with the first argument in TPS. To add the functions FNEW (6), FNEW (7) etc. simply put a JMP instruction at 4473 and look at the value of TPS. Similarly the function FDIS has been used for first arguments of 0 and 1. If FDIS is used with other arguments the program will arrive at the error return at 1300 in field 2 with the value of the first argument in INSEL.

A number of useful instructions available in the current program are listed below:

(i) Field 0

4566 - Return control to FOCAL via the error recovery routine.

JMS I 0053 - Get integer part of floating accumulator and bring it into accumulator.

4540

ARG

4566 - This instruction string will get the next argument of the function into the floating accumulator and transfer control to the following instruction. If there are no more arguments it will do an error return to FOCAL.

JMP I 0136 - Re-enter FOCAL after execution of function.

(ii) Field 2

JMP ERR - Return control to FOCAL via the error recovery routine.

JMP INSEL-12 - Returns control to FOCAL with the double precision binary number contained in the accumulator (high order word) and LOW (low order word) transferred into the floating accumulator.

JMS NEXT - Get next argument and store it in INSEL.

JMS IN2 - Get next two arguments and store them in XX and YY.

JMS IN4 - Get next four arguments and store them in X0, Y0, X1 and Y1.

3.3 Assembly, Loading and Saving

Some difficulty was experienced in assembling, loading and saving the present version of extended FOCAL. The procedure described below, while somewhat involved, has been found to work and it is strongly recommended that it be followed for future modifications.

The program segment in Field 2 should be written in a self contained form so that it can be assembled¹¹ in isolation from the rest of the program. After assembly the program segment should be single pass loaded into Field 2 and saved by

SAVE FC29! core limits; 7600.

For the required format of core limits see reference 12.

The modified program segment resident in Field 0 should be assembled into a binary file, MODS say. The two binary files comprising FOCAL, FOC1 and FOC2 along with the 8K overlay FC8K should also be on the disk. Fields 0 and 1 are then loaded as follows:

```
.  LOAD
*  IN-S:FOC1, S:FOC2, S:MODS, S:FC8K
*  OPT-2
*  ST-2000
```

[Initial dialogue^{7,8}, answer questions]

```
*  L
    (A)
    (B)
    (C)
    (D)
    A, B, C and D are four digit numbers typed by FOCAL
    following the L command.
```

Now save the program as follows:

```
.  SAVE ST9K! (D) - 7577; 2000
.  SAVE FCL9! 0 - 3377;
.  SAVE NUL9: 10100; 10113
```

Now call FCL9 by .FCL9, stop computer and remove interrupts by toggling the following patch:

Location	Old Contents	New Contents
63	2676	1354
64	2666	2414
2732	6001	2057
2762	6046	7000

Then again save FCL9 as before:

- . SAVE FCL9: Ø - 3377;

The complete modified FOCAL is then called by the following command string:

- . FC29
- . FCL9
- . CALL NUL9
- . ST9K

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Notes from Digital Equipment Seminar.
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DEC-81-H6MA-D.
Digital Equipment Publication.
11. - PAL-D Assembler.
DEC-D8-ASAA-D
Digital Equipment Publication.
12. - Disk Monitor System.
DEC-D8-SDAB-D
Digital Equipment Publication.

APPENDIX: PALD LISTING AND SYMBOL TABLE

ABC 4417
 ARG 4432
 BCD 4442
 DEF 4450
 EFG 4456
 FGH 4470
 TPS 4431
 XDYS 4476
 XFNEW 4400

		FIELD 0	
		*0035	
0035	4377	XFNEW-1	
		*0377	
0377	4476	XDYS	
		*0410	
0410	4400	XFNEW	
		*4400	
4400	4453	XFNEW, JMS I 0053	/GET FIRST ARGUMENT
4401	3231	DCA TPS	
4402	1231	TAD TPS	
4403	7440	SZA	/READ INPUT ?
4404	5217	JMP ABC	
4405	4540	4540	/PUSHJ
4406	4432	ARG	/GET NEXT ARGUMENT
4407	4566	4566	/ERROR
4410	4453	JMS I 0053	
4411	6222	6222	/INSTRUCTION FIELD 2
4412	5777	JMP 0200	
4413	4407	4407	/RETURN WITH READING IN FLAG
4414	7000	7000	/ NORMALISE
4415	0000	0000	
4416	5536	JMP I 0136	/REENTER FOCAL
4417	7000	ABC, NOP	
4420	1376	TAD (-1	
4421	7640	SZA CLA	/OUTPUT TO MACHMETER ?
4422	5242	JMP BCD	
4423	4540	4540	
4424	4432	ARG	
4425	4566	4566	
4426	4453	JMS I 0053	
4427	6222	6222	
4430	5775	JMP 0260	
4431	0000	TPS, 0000	
4432	1066	ARG, TAD 0066	/EVALUATES ADDITIONAL ARGUMENTS
4433	1374	TAD (-254	/RETURN TO CALL+2 IF ,XXX -
4434	7640	SZA CLA	/OTHERWISE CALL+1
4435	5241	JMP .+4	
4436	4540	4540	
4437	1612	1612	
4440	7001	IAC	
4441	5541	5541	/POPJ

4442	1231	BCD,	TAD TPS	
4443	1373		TAD (-2	
4444	7640		SZA CLA	/START DATA LOGGER?
4445	5250		JMP DEF	
4446	6324		6324	
4447	5536		JMP I 0136	
4450	1231	DEF,	TAD TPS	
4451	1372		TAD (-3	
4452	7640		SZA CLA	/STOP DATA LOGGER?
4453	5256		JMP EFG	
4454	6364		6364	
4455	5536		JMP I 0136	
4456	1231	EFG,	TAD TPS	
4457	1371		TAD (-4	
4460	7640		SZA CLA	/READ DATA LOGGER?
4461	5270		JMP FGH	
4462	4540		4540	
4463	4432		ARG	
4464	4566		4566	
4465	4453		JMS I 0053	
4466	6222		6222	
4467	5770		JMP 0300	
4470	1231	FGH,	TAD TPS	
4471	1367		TAD (-5	
4472	7640		SZA CLA	/CHECK RECORD FLAG
4473	4566		4566	
4474	6222		6222	
4475	5766		JMP 0342	
		*4476		
4476	4453	XDYS,	JMS I 0053	/GET FIRST ARGUMENT
4477	6222		6222	
4500	5765		JMP 0400	
		*4501		
4501	4540		4540	/GET NEXT ARGUMENT -
4502	4432		ARG	/AND RETURN TO 6604 -
4503	4566		4566	/IN FIELD 2
4504	4453		JMS I 0053	
4505	6222		6222	
4506	6221		6221	
4507	5764		JMP 6604	
4564	6604			
4565	0400			
4566	0342			
4567	7773			
4570	0300			
4571	7774			
4572	7775			
4573	7776			
4574	7524			
4575	0260			
4576	7777			
4577	0200			

A	0242
AC	1266
ADC	1217
ADL	1235
ARC	0500
B	0243
BCDBIN	6275
BCDM	6400
C	0244
CNT	0670
CT	6464
CT3	6465
DEL	0245
DELCO	0253
DEP	0240
DIAG	1651
DOUBLE	6200
DOUM	2000
DPY	6611
DSPLY	6625
ERR	6606
EXIT	1264
FLAG	1201
FORM	6613
FORMAT	6655
HIGH	6274
HIGH1	6272
INSEL	0237
IN2	1321
IN4	0424
K10	1272
K177	6327
K7	6324
K7400	6330
K7600	6325
K7760	6323
K7770	6326
LOT	1331
LOW	6273
LOW1	6271
L02	1642
MACH	0260
MB	1267
MIN	2034
M03	1270
NEG	6617
NEXT	6600
NP	0446
NUT	1650
ONEM	0272
PER	1274
PLO	1335
PLOTA	1420
PLOTDB	1531

PLOTDX 1564
 PLOTDY 1565
 PLOTMV 1567
 PLOTNA 1566
 PLOTNX 1562
 PLOTNY 1563
 PLOTPN 1561
 PLOTT1 1542
 PLOTT2 1545
 PLOTT3 1550
 PLOTWT 1570
 PLOTX 1400
 PLOT1 1427
 PLOT2 1475
 PLOT3 1516
 PLOT4 1540
 QRS 0467
 THI 2033
 TIM 1271
 TSTOR 2032
 TWO 0325
 TUOM 0273
 UDADDR 6463
 UDARND 6416
 UDBOX 6473
 UDCNT 6466
 UDCON1 6477
 UDDO 6424
 UDGET 6475
 UDHIGH 6467
 UDHSUB 6471
 UDL00P 6462
 UDL0W 6470
 UDLSUB 6472
 UDOUT 6442
 UDPTR 6476
 UDTEML 6474
 VAL 1273
 XX 1332
 XXX 6614
 XX1 1644
 X0 0474
 X1 0476
 YY 1333
 YYY 6615
 YY1 1645
 Y0 0475
 Y1 0477
 ZXY 1336

FIELD 2

*6200

/DIGITAL

8-11-U-SYM

/DOUBLE PRECISION BCD TO BINARY CONVERSION

/CALLING SEQUENCE:

/ JMS DOUBLE

```

/      ADDRESS OF HIGH ORDER ARGUMENT
/      RETURN: C(AC)=HIGH ORDER PART
/      C(LOW) = LOW ORDER PART
/ALSO CONTAINS SINGLE PRECISION BCD TO BINARY
/CALLING SEQUENCE:
/      C(AC) = 3 BCD CHARACTERS
/      JMS BCDBIN
/      RETURN: ANSWER IN C(AC)

```

```

5200 0000 DOUBLE,0
5201 7300 CLA CLL
5202 1600 TAD I DOUBLE/FETCH ADDRESS
5203 3271 DCA LOW1/STORE
5204 2200 ISZ DOUBLE/INCREMENT RETURN
5205 1671 TAD I LOW1/FETCH HIGH ORDER
5206 4275 JMS BCDBIN/CONVERT IT
5207 3272 DCA HIGH1/STORE
5210 2271 ISZ LOW1/INCREMENT POINTER
5211 1671 TAD I LOW1/FETCH LOW ORDER
5212 4275 JMS BCDBIN/CONVERT IT
5213 3271 DCA LOW1/STORE IT
5214 1272 TAD HIGH1
5215 7112 CLL RTR
5216 7012 RTR
5217 7010 RAR/MULTIPLY HIGH ORDER
5220 3275 DCA BCDBIN/PART BY 128
5221 1275 TAD BCDBIN
5222 0327 AND K177
5223 3274 DCA HIGH
5224 1275 TAD BCDBIN
5225 7010 RAR
5226 0325 AND K7600
5227 3273 DCA LOW
5230 1272 TAD HIGH1/MULTIPLY HIGH ORDER
5231 7104 CLL RAL/BY THREE
5232 1272 TAD HIGH1/FORM 128*HIGH-3*HIGH
5233 7141 CIA CLL
5234 1273 TAD LOW
5235 3273 DCA LOW
5236 7420 SNL
5237 7040 CMA
5240 1274 TAD HIGH
5241 3274 DCA HIGH/125*HIGH
5242 1274 TAD HIGH/NOW MULTIPLY BY 8
5243 7106 CLL RTL
5244 7004 RAL
5245 0326 AND K7770/MASK 9 BITS
5246 3274 DCA HIGH
5247 1273 TAD LOW
5250 7106 CLL RTL
5251 7004 RAL
5252 3273 DCA LOW
5253 1273 TAD LOW
5254 7004 RAL
5255 0324 AND K7/3 BITS
5256 1274 TAD HIGH
5257 3274 DCA HIGH

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6260	1273	TAD LOW
6261	0326	AND K7770/9 BITS
6262	7100	CLL
6263	1271	TAD LOW1/ADD LOW ORDER PART
6264	3273	DCA LOW/STORE LOW ORDER PART
6265	1274	TAD HIGH
6266	7430	SZL
6267	7001	IAC/CARRY
6270	5600	JMP I DOUBLE
6271	0000	LOW1,0
6272	0000	HIGH1,0
6273	0000	LOW,0
6274	0000	HIGH,0
		/SINGLE PRECISION CONVERSION
6275	0000	BCDBIN,0
6276	3274	DCA HIGH
6277	1274	TAD HIGH
6300	0330	AND K7400/LEFT DIGIT
6301	7112	CLL RTR
6302	3273	DCA LOW
6303	1273	TAD LOW
6304	7010	RAR
6305	1273	TAD LOW
6306	7041	CIA
6307	1274	TAD HIGH
6310	3274	DCA HIGH
6311	1274	TAD HIGH
6312	0323	AND K7760
6313	7112	CLL RTR
6314	3273	DCA LOW
6315	1273	TAD LOW
6316	7010	RAR
6317	1273	TAD LOW
6320	7041	CIA
6321	1274	TAD HIGH
6322	5675	JMP I BCDBIN
6323	7760	K7760,7760
6324	0007	K7,7
6325	7600	K7600,7600
6326	7770	K7770,7770
6327	0177	K177,177
6330	7400	K7400,7400
		FIELD 2
		*6400
6400	0000	BCDM, 0
6401	3270	DCA UBLOW
6402	1600	TAD I BCDM
6403	3267	DCA UDHIGH
6404	1262	TAD UDLOOP
6405	3266	DCA UDCNT
6406	1263	TAD UBADDR
6407	3276	DCA UDPTR
6410	2200	ISZ BCDM
6411	1377	TAD (-2
6412	3264	DCA CT
6413	1376	TAD (-3

6414	3265		DCA CT3
6415	3273		DCA UDBOX
6416	1676	UDARND,	TAD I UDPTR
6417	2276		ISZ UDPTR
6420	3271		DCA UDHSUB
6421	1676		TAD I UDPTR
6422	2276		ISZ UDPTR
6423	3272		DCA UDLSUB
6424	7100	UDDO,	CLL
6425	1272		TAD UDLSUB
6426	1270		TAD UDLW
6427	3274		DCA UDTEHL
6430	7004		RAL
6431	1271		TAD UDHSUB
6432	1267		TAD UDHIGH
6433	7420		SNL
6434	5242		JMP UDOUT
6435	2273		ISZ UDBOX
6436	3267		DCA UDHIGH
6437	1274		TAD UDTEHL
6440	3270		DCA UDLW
6441	5224		JMP UDDO
6442	7200	UDOUT,	CLA
6443	1273		TAD UDBOX
6444	2265		ISZ CT3
6445	7410		SKP
6446	5254		JMP .+6
6447	7106		CLL RTL
6450	7106		CLL RTL
6451	3273		DCA UDBOX
6452	2266		ISZ UDCNT
6453	5216		JMP UDARND
6454	2264		ISZ CT
6455	3775		DCA ONEM
6456	3774		DCA TWOM
6457	2266		ISZ UDCNT
6460	5213		JMP UDARND-3
6461	5600		JMP I BCDM
6462	7772	UDLOOP,	-6
6463	6477	UDADDR,	UDCON1
6464	0000	CT,	0
6465	0000	CT3,	0
6466	0000	UDCNT,	0
6467	0000	UDHIGH,	0
6470	0000	UDLW,	0
6471	0000	UDHSUB,	0
6472	0000	UDLSUB,	0
6473	0000	UDBOX,	0
6474	0000	UDTEHL,	0
6475	0000	UDGET,	0
6476	0000	UDPTR,	0
6477	7747	UDCON1,	7747
6500	4540		4540
6501	7775		7775 /-10,
6502	4360		4360
6503	7777		7777

6504	6030	6030
6505	7777	7777
6506	7634	7634
6507	7777	7777
6510	7766	7766
6511	7777	7777
6512	7777	7777

/END TAPE 4

PAUSEFIELD 2

6574	0273
6575	0272
6576	7775
6577	7776

*0200

0200	6221	6221
0201	3237	DCA INSEL
0202	6334	6334
0203	6331	6331
0204	1237	TAD INSEL
0205	6334	6334
0206	7300	CLA CLL
0207	4245	JMS DEL
0210	7300	CLA CLL
0211	6332	6332
0212	3240	DCA DEP
0213	1237	TAD INSEL
0214	6334	6334
0215	7300	CLA CLL
0216	4245	JMS DEL
0217	7300	CLA CLL
0220	6322	6322
0221	3241	DCA DEP+1
0222	6334	6334
0223	4777	JMS DOUM
0224	7000	NOP
0225	6201	6201
0226	3642	DCA I A
0227	6221	6221
0230	1776	TAD LOW
0231	6201	6201
0232	3643	DCA I B
0233	1375	TAD (27
0234	3644	DCA I C
0235	6202	6202
0236	5774	JMP 4413
0237	0000	INSEL, 0000
0240	0000	DEP, 0000
0241	0000	0000
0242	0045	A, 0045
0243	0046	B, 0046
0244	0044	C, 0044
0245	0000	DEL, 0000
0246	1373	TAD (7470
0247	3253	DCA DELCO
0250	2253	ISZ DELCO
0251	5250	JMP .-1

/FNEW(0)

/DATA FIELD 2

/DEVICE NUMBER

/LOAD INPUT SELECTOR

/CLEAR RECORD FLAG

/LOAD INPUT SELECTOR

/READ BYTE 2

/READ BYTE 1

/0 IN INPUT SELECTOR

/CONVERT TO BINARY

0252	5645		JMP I DEL	
0253	0000	DELCO,	0000	
		*260		
0260	6221	MACH,	6221	/FNEW(1)
0261	4772		JMS BCDM	
0262	0000		0	
0263	1273		TAD TWOM	
0264	6304		6304	
0265	7300		CLA CLL	
0266	1272		TAD ONEM	
0267	6316		6316	
0270	7300		CLA CLL	
0271	5225		JMP INSEL-12	
0272	0000	ONEM,	0000	
0273	0000	TWOM,	0000	
		*300		
0300	6221		6221	/FNEW(4)
0301	7000		NOP	
0302	3237		DCA INSEL	
0303	1237		TAD INSEL	
0304	7440		SZA	/SKIP FOR FIRST BYTE
0305	5325		JMP TWO	
0306	6351		6351	/CLEAR DATA LOGGER FLAG
0307	6341		6341	/SKIP ON DATA LOGGER FLAG
0310	5307		JMP .-1	
0311	7300		CLA CLL	
0312	6344		6344	/READ BYTE 1
0313	6351		6351	/CLEAR FLAG
0314	4771		JMS BCDBIN	
0315	6201		6201	
0316	3643		DCA I B	
0317	3642		DCA I A	
0320	1375		TAD (27	
0321	3644		DCA I C	
0322	7000		NOP	
0323	6202		6202	
0324	5774		JMP 4413	
0325	7300	TWO,	CLA CLL	
0326	6341		6341	/SKIP ON FLAG
0327	5331		JMP .+2	
0330	7402		HLT	/TIMING FOUL UP
0331	7300		CLA CLL	
0332	6352		6352	/READ BYTE 2
0333	3240		DCA DEP	
0334	6354		6354	/READ BYTE 3
0335	3241		DCA DEP+1	
0336	7000		NOP	
0337	5223		JMP INSEL-14	/RETURN WITH DATA
		*342		/FNEW(5)
0342	6221		6221	
0343	6311		6311	
0344	5351		JMP .+5	
0345	6331		6331	
0346	7200		CLA	
0347	7001		IAC	
0350	5225		JMP INSEL-12	

0351	7200	CLA	
0352	3776	DCA LOW	
0353	5225	JMP INSEL-12	
0371	6275		
0372	6400		
0373	7470		
0374	4413		
0375	0027		
0376	6273		
0377	2000		
	*400		
0400	6221	6221	/FDIS
0401	3777	DCA INSEL	/FIRST ARGUMENT
0402	1777	TAD INSEL	
0403	7440	SZA	/SCREEN?
0404	5776	JMP PER	/PLOTTER
0405	4775	JMS NEXT	/GET NEXT ARGUMENT
0406	7300	CLA CLL	
0407	1777	TAD INSEL	
0410	7440	SZA	
0411	5216	JMP .+5	
0412	1374	TAD (0004	/ERASE SCREEN
0413	3773	DCA FORM	
0414	4772	JMS DPY	
0415	5771	JMP INSEL-12	
0416	1370	TAD (7777	
0417	7640	SZA CLA	/LINEAR VECTOR?
0420	5300	JMP ARC	
0421	4224	JMS IN4	
0422	4246	JMS NP	
0423	5267	JMP ORS	
0424	0000	IN4, 0	/GETS X0,X1,Y0&Y1
0425	4775	JMS NEXT	
0426	1777	TAD INSEL	
0427	4767	JMS NEG	
0430	3274	DCA X0	
0431	4775	JMS NEXT	
0432	1777	TAD INSEL	
0433	4767	JMS NEG	
0434	3275	DCA Y0	
0435	4775	JMS NEXT	
0436	1777	TAD INSEL	
0437	4767	JMS NEG	
0440	3276	DCA X1	
0441	4775	JMS NEXT	
0442	1777	TAD INSEL	
0443	4767	JMS NEG	
0444	3277	DCA Y1	
0445	5624	JMP I IN4	
0446	0000	NP, 0	/INVISIBLE VECTOR TO X0,Y0
0447	1366	TAD (0002	
0450	3773	DCA FORM	/RESET INTEGRATORS
0451	4772	JMS DPY	
0452	1274	TAD X0	
0453	3765	DCA XXX	
0454	1275	TAD Y0	

0455	3764		DCA YYY	
0456	1363		TAD (0440	/INVISIBLE VECTOR
0457	3773		DCA FORM	
0460	4772		JMS DPY	
0461	7300		CLA CLL	
0462	1276		TAD X1	/GET X1&Y1
0463	3765		DCA XXX	
0464	1277		TAD Y1	
0465	3764		DCA YYY	
0466	5646		JMP I NP	
0467	7300	QRS,	CLA CLL	
0470	1362		TAD (0441	/VISIBLE VECTOR
0471	3773		DCA FORM	
0472	4772		JMS DPY	
0473	5771		JMP INSEL-12	
0474	0000	X0,	0	
0475	0000	Y0,	0	
0476	0000	X1,	0	
0477	0000	Y1,	0	
0500	1777	ARC,	TAD INSEL	
0501	1361		TAD (7776	
0502	7640		SZA CLA	/SHORT ARC?
0503	5312		JMP .+7	
0504	4224		JMS IN4	
0505	4246		JMS NP	
0506	1360		TAD (0211	
0507	3773		DCA FORM	
0510	4772		JMS DPY	
0511	5771		JMP INSEL-12	
0512	1777		TAD INSEL	
0513	1357		TAD (7775	
0514	7640		SZA CLA	/LONG ARC?
0515	5324		JMP .+7	
0516	4224		JMS IN4	
0517	4246		JMS NP	
0520	1356		TAD (0051	
0521	3773		DCA FORM	
0522	4772		JMS DPY	
0523	5771		JMP INSEL-12	
0524	1777		TAD INSEL	
0525	1355		TAD (7774	
0526	7640		SZA CLA	/DISPLAY CURSOR?
0527	5335		JMP .+6	
0530	7300		CLA CLL	
0531	1354		TAD (1400	
0532	3773		DCA FORM	
0533	4772		JMS DPY	
0534	5771		JMP INSEL-12	
0535	1777		TAD INSEL	
0536	1353		TAD (7773	
0537	5752		JMP 600	
0552	0600			
0553	7773			
0554	1400			
0555	7774			
0556	0051			

0557 7775
 0560 0211
 0561 7776
 0562 0441
 0563 0440
 0564 6615
 0565 6614
 0566 0002
 0567 6617
 0570 7777
 0571 0225
 0572 6611
 0573 6613
 0574 0004
 0575 6600
 0576 1274
 0577 0237

0600 7640
 0601 5210
 0602 4777
 0603 4776
 0604 1375
 0605 3774
 0606 4773
 0607 5772
 0610 1771
 0611 1370
 0612 7640
 0613 5231
 0614 4777
 0615 1767
 0616 1366
 0617 3767
 0620 4776
 0621 1365
 0622 3270
 0623 1364
 0624 3774
 0625 4773
 0626 2270
 0627 5225
 0630 5772
 0631 1771
 0632 1363
 0633 7640
 0634 5762
 0635 4777
 0636 1767
 0637 1361
 0640 3767
 0641 1760
 0642 1366
 0643 3760
 0644 4776
 0645 1357

*600

SZA CLA
 JMP .+7
 JMS IN4
 JMS NP
 TAD (1001
 DCA FORM
 JMS DPY
 JMP INSEL-12
 TAD INSEL
 TAD (7772
 SZA CLA
 JMP .+16
 JMS IN4
 TAD X0
 TAD (5
 DCA X0
 JMS NP
 TAD (7774
 DCA CNT
 TAD (0051
 DCA FORM
 JMS DPY
 ISZ CNT
 JMP .-2
 JMP INSEL-12
 TAD INSEL
 TAD (7771
 SZA CLA
 JMP 800
 JMS IN4
 TAD X0
 TAD (-5
 DCA X0
 TAD X1
 TAD (5
 DCA X1
 JMS NP
 TAD (0441

/POINT?

/CIRCLE SYMBOL?

/CROSS SYMBOL?

0646	3774	DCA FORM	
0647	4773	JMS DPY	
0650	1767	TAD X0	
0651	1366	TAD (5	
0652	3767	DCA X0	
0653	1767	TAD X0	
0654	3760	DCA X1	
0655	1756	TAD Y0	
0656	1361	TAD (-5	
0657	3756	DCA Y0	
0660	1755	TAD Y1	
0661	1366	TAD (5	
0662	3755	DCA Y1	
0663	4776	JMS NP	
0664	1357	TAD (0441	
0665	3774	DCA FORM	
0666	4773	JMS DPY	
0667	5772	JMP INSEL-12	
0670	0000	CNT,	0
0755	0477		
0756	0475		
0757	0441		
0760	0476		
0761	7773		
0762	1000		
0763	7771		
0764	0051		
0765	7774		
0766	0005		
0767	0474		
0770	7772		
0771	0237		
0772	0225		
0773	6611		
0774	6613		
0775	1001		
0776	0446		
0777	0424		
		*800	
1000	1777	TAD INSEL	
1001	1376	TAD (7770	
1002	7640	SZA CLA	/READ X CURSOR?
1003	5212	JMP .+7	
1004	1375	TAD (1400	
1005	6062	6062	
1006	4774	JMS ADC	
1007	3773	DCA LOW	
1010	4772	JMS MIN	/SORT OUT NEGATIVE SIGN
1011	5771	JMP INSEL-12	
1012	1777	TAD INSEL	
1013	1370	TAD (7767	
1014	7640	SZA CLA	/READ Y CURSOR
1015	5767	JMP FLAG	
1016	1366	TAD (1440	
1017	6062	6062	
1020	4774	JMS ADC	

1021	3773	DCA LOW
1022	4772	JMS MIN
1023	5771	JMP INSEL-12
1166	1440	
1167	1201	
1170	7767	
1171	0225	
1172	2034	
1173	6273	
1174	1217	
1175	1400	
1176	7770	
1177	0237	

*6600		
6600	0000	NEXT, 0 /GETS NEXT ARGUMENT

6601	6201	6201
6602	6202	6202
6603	5777	JMP 4501
6604	3776	DCA INSEL
6605	5600	JMP I NEXT
6606	6201	ERR, 6201
6607	6202	6202
6610	5775	JMP 4425

/ERROR RETURN

6611	0000	DPY, 0
6612	4225	JMS DSPLY
6613	0000	FORM, 0
6614	0000	XXX, 0
6615	0000	YYY, 0
6616	5611	JMP I DPY
6617	0000	NEG, 0

/SORTS OUT NEGATIVE SIGN -
/OF CURSOR LOCATION

6620	7500	SMA
6621	5617	JMP I NEG
6622	0374	AND (0777
6623	1373	TAD (1000
6624	5617	JMP I NEG
6625	0000	DSPLY, 0

/SUBROUTINE TO DRIVE DISPLAY

6626	7300	CLA CLL
6627	1625	TAD I DSPLY
6630	2225	ISZ DSPLY
6631	6063	6063
6632	3255	DCA FORMAT
6633	1625	TAD I DSPLY
6634	6064	6064
6635	7200	CLA
6636	2225	ISZ DSPLY
6637	6071	6071
6640	5237	JMP .-1
6641	1625	TAD I DSPLY
6642	6065	6065
6643	7200	CLA
6644	2225	ISZ DSPLY
6645	6071	6071
6646	5245	JMP .-1
6647	1255	TAD FORMAT
6650	6066	6066
6651	7200	CLA

```

6652 6071          6071
6653 5252          JMP .-1
6654 5625          JMP I DSPLY
6655 0000  FORMAT, 0
                PAUSE
                /DIGITAL 8-12-U
                /PLOT SUBROUTINE
                /CALLING SEQUENCE
                /  C(AC)=-1; INITIALIZE
                /  C(AC)= 0; PLOT WITH PEN DOWN
                /  C(AC)= 1; PLOT WITH PEN UP
                /    JMS PLOTX
                /    X CO-ORDINATE (IN STEPS) (RETURN IF AC=-1)
                /    Y CO-ORDINATE (IN STEPS)
                FIELD 2

```

```

6773 1000
6774 0777
6775 4425
6776 0237
6777 4501

```

```

                *1400
1400 0000  PLOTX, 0
1401 7510          SPA                /MOVE THE PEN?
1402 5220          JMP PLOTA          /NO: CONTINUE
1403 1361          TAD PLOTPN        /ADD PEN STATUS
1404 7112          CLL RTR
1405 7710          SPA CLA                /ANY CHANGE?
1406 5227          JMP PLOT1          /NO: CONTINUE
1407 7620          SNL CLA
1410 5214          JMP .+4                /LOWER THE PEN
1411 3361          DCA PLOTPN        /RAISE THE PEN
1412 6504          6504
1413 5216          JMP .+3
1414 2361          ISZ PLOTPN        /LOWER THE PEN
1415 6524          6524
1416 4370          JMS PLOTWT        /WAIT FOR FLAG
1417 5227          JMP PLOT1          /CONTINUE
1420 7200  PLOTA, CLA
1421 6504          6504
1422 3361          DCA PLOTPN
1423 3362          DCA PLOTNX        /0 TO X CO-ORDINATE
1424 3363          DCA PLOTNY        /0 TO Y CO-ORDINATE
1425 4370          JMS PLOTWT
1426 5600          JMP I PLOTX

```

```

                /DIGITAL 8-12-U
                /PAGE 2
                /PICK UP ARGUMENTS
1427 1362  PLOT1,TAD PLOTNX /FETCH PREVIOUS X CO-ORDINATE
1430 7141  CIA CLL
1431 1600  TAD I PLOTX /FORM NX-MPX
1432 7420  SNL /L=0: NX<NPX
1433 7041  CIA
1434 3364  DCA PLOTDX /ABSOLUTE VALUE OF DIFFERENCE
1435 7004  RAL
1436 3367  DCA PLOTMV /SAVE SIGN BIT
1437 1600  TAD I PLOTX /SET NEU

```


1440	3362	DCA PLOTNX /PREVIOUS X
1441	2200	ISZ PLOTX /INCREMENT POINTER
1442	1363	TAD PLOTNY /FETCH PREVIOUS Y CO-ORDINATE
1443	7141	CIA CLL
1444	1600	TAD I PLOTX /FORM NY-NPY
1445	7420	SNL /<=0: NPY<NY
1446	7041	CIA
1447	3365	DCA PLOTDY /ABSOLUTE VALUE OF DIFFERENCE
1450	1367	TAD PLOTMV /SAVE SIGN BIT
1451	7004	RAL /BIT 10(1)= DRUM-DOWN(POSITIVE)
1452	3367	DCA PLOTMV /BIT 11(1)=PEN-LEFT (POSITIVE)
1453	1600	TAD I PLOTX /SET NEW
1454	3363	DCA PLOTNY /PREVIOUS Y
1455	2200	ISZ PLOTX /INCREMENT POINTER
1456	1364	TAD PLOTDX
1457	7141	CIA CLL
1460	1365	TAD PLOTDY
1461	7420	SNL CLA /L=0: DELTA Y < DELTA X
1462	5275	JMP PLOT2
1463	1364	TAD PLOTDX /REVERSE NUMBERS
1464	3366	DCA PLOTNA
1465	1365	TAD PLOTDY
1466	3364	DCA PLOTDX
1467	1366	TAD PLOTNA
1470	3365	DCA PLOTDY
1471	7001	IAC /SET MAJOR MOTION
1472	0367	AND PLOTMV /INSTRUCTION
1473	1342	TAD PLOTT1
1474	5300	JMP .+4
		/DIGITAL 8-12-U
		/PAGE 3
1475	1367	PLOT2,TAD PLOTMV
1476	7110	CLL RAR
1477	1345	TAD PLOTT2
1500	3366	DCA PLOTNA
1501	1766	TAD I PLOTNA
1502	3340	DCA PLOT4
1503	1367	TAD PLOTMV /SET COMBINED MOTION
1504	1350	TAD PLOTT3
1505	3367	DCA PLOTMV
1506	1767	TAD I PLOTMV
1507	3331	DCA PLOTDB
1510	1364	TAD PLOTDX
1511	7110	CLL RAR
1512	3366	DCA PLOTNA
1513	1364	TAD PLOTDX
1514	7040	CMA
1515	3367	DCA PLOTMV
1516	2367	PLOT3,ISZ PLOTMV
1517	7410	SKP
1520	5600	JMP I PLOTX /ALL DONE
1521	1366	TAD PLOTNA
1522	1365	TAD PLOTDY
1523	3366	DCA PLOTNA
1524	1366	TAD PLOTNA
1525	7140	CMA CLL

1526	1364	TAD PLOTDX
1527	7630	SZL CLA
1530	5340	JMP PLOT4 /SINGLE MOTION
1531	0000	PLOTDB,0 /COMBINED MOTION
1532	1364	TAD PLOTDX
1533	7041	CIA
1534	1366	TAD PLOTNA
1535	3366	DCA PLOTNA
1536	4370	JMS PLOTWT
1537	5316	JMP PLOT3
1540	0000	PLOT4,0
1541	5336	JMP .-3
1542	1543	PLOTT1, .+1
1543	6511	6511
1544	6521	6521
1545	1546	PLOTT2, .+1
1546	6512	6512
1547	6514	6514
1550	1551	PLOTT3, .+1
1551	6513	6513
1552	6523	6523
1553	6515	6515
1554	4355	JMS .+1 /DOWN-LEFT
1555	0000	0
1556	6514	6514
1557	6521	6521
1560	5755	JMP I .-3
		/DIGITAL 8-12-U
		/PAGE 4
1561	0000	PLOTPN,0
1562	0000	PLOTNX,0
1563	0000	PLOTNY,0
1564	0000	PLOTDX,0
1565	0000	PLOTBY,0
1566	0000	PLOTNA,0
1567	0000	PLOTNV,0
1570	0000	PLOTWT,0
1571	6501	6501
1572	5371	JMP .-1 /NOT YET
1573	6502	6502
1574	5770	JMP I PLOTWT /EXIT
		PAUSE FIELD 2
		*1200
1200	7000	NOP
1201	1777	FLAG, TAD INSEL
1202	1376	TAD (7766
1203	7640	SZA CLA
1204	5775	JMP ERR
1205	6051	6051
1206	5210	JMP .+2
1207	5214	JMP .+5
1210	6052	6052
1211	7200	CLA
1212	7001	IAC
1213	7510	SPA
1214	7200	CLA

/GET STATE OF CURSOR FLAG

1215	3774		DCA LOW	
1216	5773		JMP INSEL-12	
1217	0000	ADC,	0	/SUBROUTINE TO READ -
1220	7200		CLA	/CURSOR LOCATION
1221	6074		6074	
1222	1270		TAD M03	
1223	3271		DCA TIM	
1224	2271		ISZ TIM	
1225	5224		JMP .-1	
1226	6073		6073	
1227	7410		SKP	
1230	1272		TAD K10	
1231	3266		DCA AC	
1232	1272		TAD K10	
1233	3267		DCA MB	
1234	1266		TAD AC	
1235	3273	ADL,	DCA VAL	
1236	1267		TAD MB	
1237	7110		RAR CLL	
1240	7430		SZL	
1241	5264		JMP EXIT	
1242	3267		DCA MB	
1243	1267		TAD MB	
1244	1266		TAD AC	
1245	3266		DCA AC	
1246	1266		TAD AC	
1247	6074		6074	
1250	7200		CLA	
1251	1270		TAD M03	
1252	3271		DCA TIM	
1253	2271		ISZ TIM	
1254	5253		JMP .-1	
1255	6073		6073	
1256	5262		JMP .+4	
1257	1273		TAD VAL	
1260	3266		DCA AC	
1261	5236		JMP ADL+1	
1262	1266		TAD AC	
1263	5235		JMP ADL	
1264	1273	EXIT,	TAD VAL	
1265	5617		JMP I ADC	
1266	0000	AC,	0	
1267	0000	MB,	0	
1270	7750	M03,	7750	
1271	0000	TIM,	0	
1272	1000	K10,	1000	
1273	0000	VAL,	0	
1274	7300	PER,	CLA CLL	
1275	1777		TAD INSEL	
1276	1372		TAD (7777	
1277	7440		SZA	
1300	5775		JMP ERR	
1301	4771		JMS NEXT	
1302	7300		CLA CLL	
1303	1777		TAD INSEL	
1304	7440		SZA	

1305	5311		JMP .+4	
1306	7240		CLA CMA	
1307	4735		JMS I PLO	
1310	5773		JMP INSEL-12	
1311	7300		CLA CLL	
1312	1777		TAD INSEL	
1313	1372		TAD (7777	
1314	7440		SZA	/PLOT PEN UP?
1315	5336		JMP ZXY	
1316	4321		JMS IN2	
1317	7201		CLA IAC	
1320	5331		JMP LOT	
1321	0000	IN2,	0	
1322	4771		JMS NEXT	
1323	1777		TAD INSEL	
1324	3333		DCA YY	
1325	4771		JMS NEXT	
1326	1777		TAD INSEL	
1327	3332		DCA XX	
1330	5721		JMP I IN2	
1331	4735	LOT,	JMS I PLO	
1332	0000	XX,	0	
1333	0000	YY,	0	
1334	5773		JMP INSEL-12	
1335	1400	PLD,	PLDIX	
1336	7300	ZXY,	CLA CLL	
1337	1777		TAD INSEL	
1340	1370		TAD (7776	
1341	7440		SZA	/PLOT PEN DOWN?
1342	5767		JMP 1600	
1343	4321		JMS IN2	
1344	7200		CLA	
1345	5331		JMP LOT	
1367	1600			
1370	7776			
1371	6600			
1372	7777			
1373	0225			
1374	6273			
1375	6606			
1376	7766			
1377	0237			
1600	7300		*1600	
1601	1777		CLA CLL	
1602	1376		TAD INSEL	
1603	7440		TAD (7775	
1604	5251		SZA	/PLOT + SYMBOL?
1605	4775		JMP DIA6	
1606	1774		JMS IN2	
1607	1373		TAD XX	
1610	3244		TAD (-10	
1611	1772		DCA XX1	
1612	3245		TAD YY	
1613	7201		DCA YY1	
1614	4242		CLA IAC	
			JMS LQ2	

1615	1774		TAD XX
1616	1371		TAD (10
1617	3244		DCA XX1
1620	7200		CLA
1621	4242		JMS L02
1622	1774		TAD XX
1623	3244		DCA XX1
1624	7200		CLA
1625	4242		JMS L02
1626	1774		TAD XX
1627	3244		DCA XX1
1630	1772		TAD YY
1631	1371		TAD (10
1632	3245		DCA YY1
1633	7201		CLA IAC
1634	4242		JMS L02
1635	1772		TAD YY
1636	1373		TAD (-10
1637	3772		DCA YY
1640	7200		CLA
1641	5770		JMP L0T
1642	0000	L02,	0
1643	4650		JMS I NUT
1644	0000	XX1,	0
1645	0000	YY1,	0
1646	7300		CLA CLL
1647	5642		JMP I L02
1650	1400	NUT,	PLOTX
1651	7300	DIAG,	CLA CLL
1652	1777		TAD INSEL
1653	1367		TAD (7774
1654	7440		SZA
1655	5766		JMP ERR
1656	4775		JMS IN2
1657	1774		TAD XX
1660	1365		TAD (-5
1661	3244		DCA XX1
1662	1772		TAD YY
1663	1364		TAD (5
1664	3245		DCA YY1
1665	7201		CLA IAC
1666	4242		JMS L02
1667	1774		TAD XX
1670	1364		TAD (5
1671	3244		DCA XX1
1672	1772		TAD YY
1673	1365		TAD (-5
1674	3245		DCA YY1
1675	7200		CLA
1676	4242		JMS L02
1677	1774		TAD XX
1700	1365		TAD (-5
1701	3244		DCA XX1
1702	1772		TAD YY
1703	1365		TAD (-5
1704	3245		DCA YY1

/PLOT X SYMBOL

1705	7201	CLA IAC
1706	4242	JMS LO2
1707	1774	TAD XX
1710	1364	TAD (5
1711	3774	DCA XX
1712	1772	TAD YY
1713	1364	TAD (5
1714	3772	DCA YY
1715	7200	CLA
1716	5770	JMP LOT

1764	0005
1765	7773
1766	6606
1767	7774
1770	1331
1771	0010
1772	1333
1773	7770
1774	1332
1775	1321
1776	7775
1777	0237

2000	0000	DOUM,	*2000
2001	7300		0
2002	1777		CLL CLA
2003	0376		TAD DEP
2004	3232		AND (0020
2005	1777		DCA TSTOR
2006	0375		TAD DEP
2007	3777		AND (0017
2010	4774		DCA DEP
2011	0240		JMS DOUBLE
2012	3233		DEP
2013	1232		DCA THI
2014	7450		TAD TSTOR
2015	5227		SNA
2016	7300		JMP .+12
2017	1773		CLA CLL
2020	7041		TAD LOW
2021	3773		CIA
2022	1233		DCA LOW
2023	7040		TAD THI
2024	7430		CMA
2025	7001		SZL
2026	3233		IAC
2027	1233		DCA THI
2030	7100		TAD THI
2031	5600		CLL
2032	0000	TSTOR,	JMP I DOUM
2033	0000	THI,	0
2034	0000	MIN,	0
2035	7300		0
2036	1773		CLL CLA
2037	1177		TAD LOW
2040	7710		TAD(-0454
			SPA CLA

/SORTS OUT SIGN FOR -
/DOUBLE PRECISION BCD -
/TO BINARY CONVERSION

2041	5634	JMP I MIN
2042	7300	CLL CLA
2043	1773	TAD LOW
2044	1372	TAD (-2000
2045	7000	NOP
2046	3773	DCA LOW
2047	7300	CLL CLA
2050	7040	CMA
2051	7430	SZL
2052	7101	CLL IAC
2053	5634	JMP I MIN
2172	6000	
2173	6273	
2174	6200	
2175	0017	
2176	0020	
2177	0240	
0177	7324	

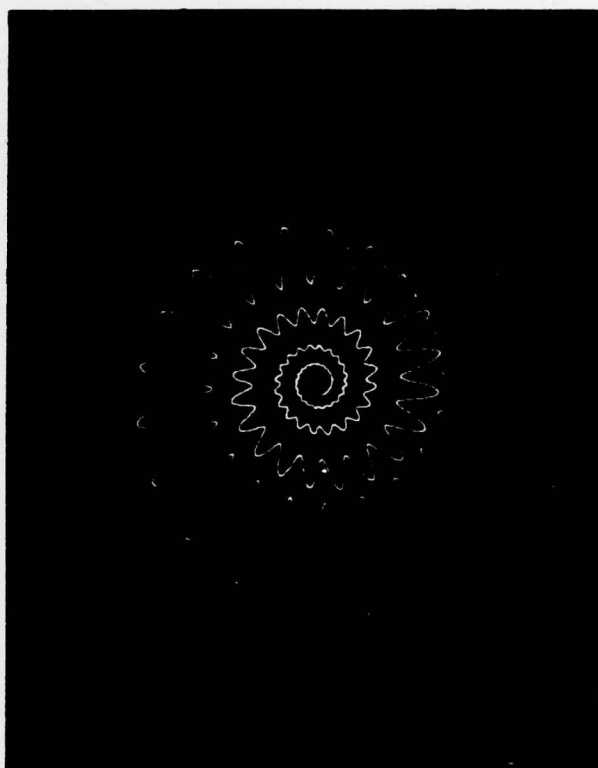


FIG. 1 EXAMPLE OF FUNCTION PLOTTING ON SCREEN

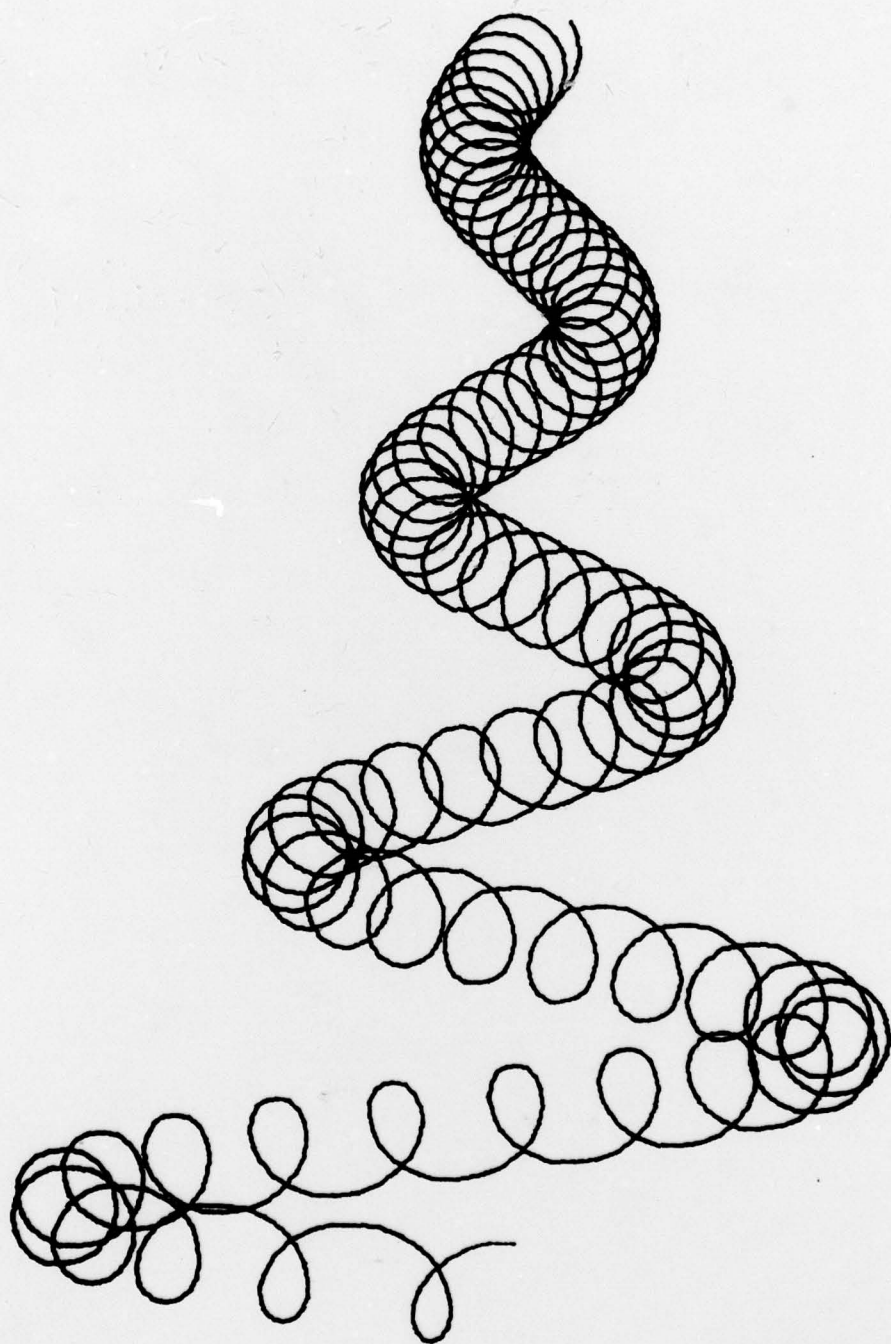


FIG. 2 EXAMPLE OF FUNCTION PLOTTING ON PLOTTER

DOCUMENT CONTROL DATA SHEET

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PROCESSING INSTALLATION - PART 7 - EXTENDED FOCAL

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| <p>4. PERSONAL AUTHOR:</p> <p>N. POLLOCK</p> | <p>5. DOCUMENT DATE:
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13. ANNOUNCEMENT LIMITATIONS (of the information on this page):

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| <p>14. DESCRIPTORS:</p> <p>Computer Programs</p> <p>Transonic Wind Tunnels</p> <p>Data Processing</p> <p>Computer Systems Programs</p> | <p>15. COSATI CODES:</p> <p>0902</p> <p>1402</p> |
|--|--|

16. ABSTRACT:

Since the transonic wind tunnel data processing installation which is based on a PDP 8-I computer, was installed in 1968 a considerable library of standard programs have been produced. This program library covers all types of testing commonly carried out in the wind tunnel. However, there remains the possibility of unusual tests being required which are not covered by existing programs.

This memorandum describes modifications to the Digital Equipment Corporation FOCAL language (FOCAL is a keyboard oriented interpretive language similar to BASIC) which permit the tunnel instrumentation, display and plotter to be operated by FOCAL programs. Using this extended FOCAL language it should be possible to rapidly write and de-bug programs to meet unusual requirements not covered by the standard program library.

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